THE WEATHER AND CIRCULATION OF JUNE 1956[1]

Another Hot June in Central United States

RAYMOND A. GREEN

Extended Forecast Section, U. S. Weather Bureau, Washington, D. C.

1. INTRODUCTION

June 1956 was characterized by abnormal warmth over central United States. This represented a marked reversal from last year but followed the trend of June temperatures for the three previous years, when heat waves were produced over central and eastern United States [1]. This time the heat wave area was centered farther west than in Junes from 1952 to 1954, and above normal temperatures dominated the country from the Southwest through the Great Plains to the Great Lakes

[1] See Charts I–XVII following p. 252 for analyzed climatological data for the month.

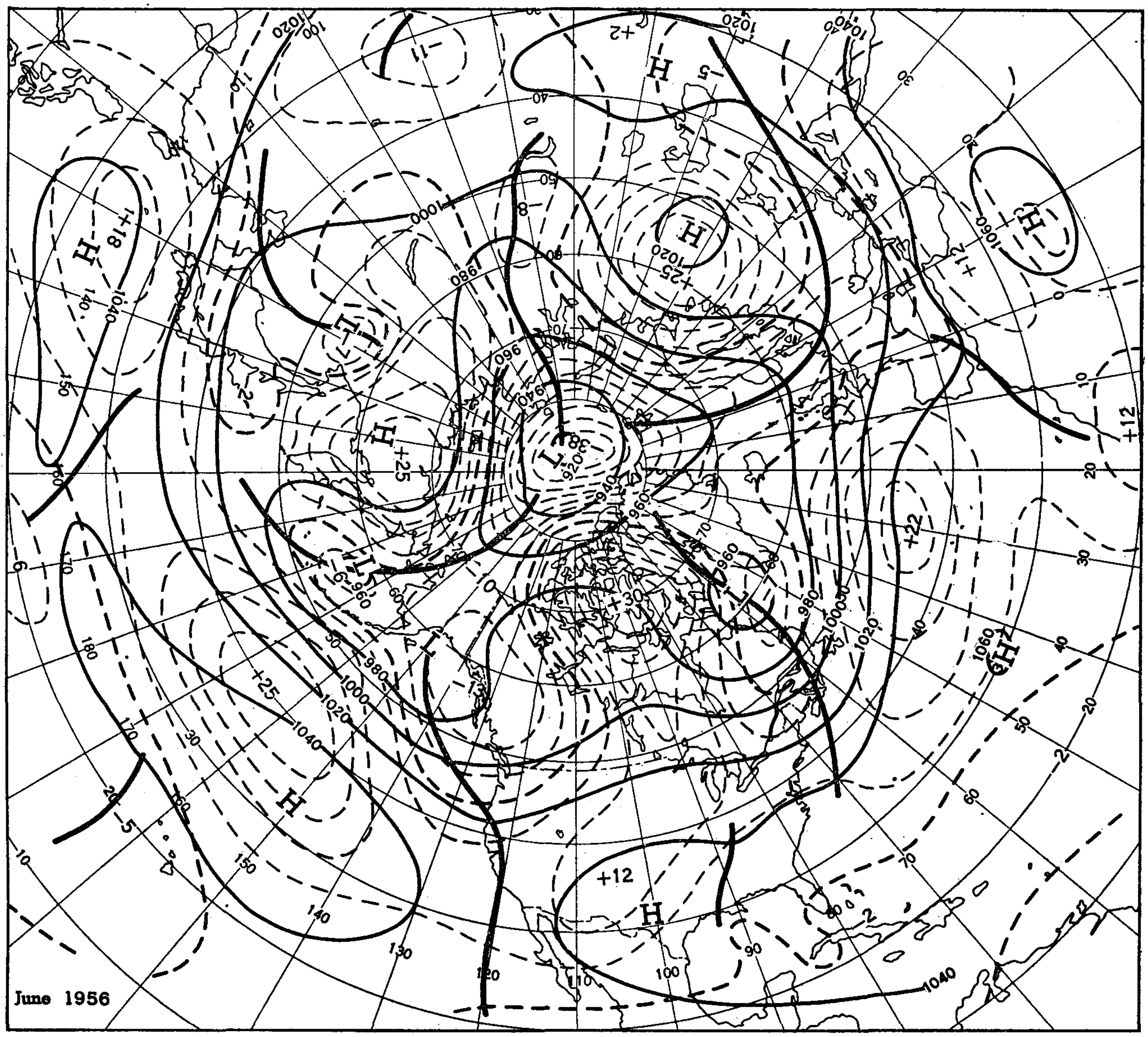


FIGURE 1.—Monthly mean 700-mb. height contours and departures from normal (both in tens of feet) for June 1956. Note large height anomaly center (−350 ft.) near the North Pole and centers of blocking activity in northeastern Canada and Siberia and northern Russia. The subtropical anticyclone belt appears north of its usual position and stronger than normal from mid-Pacific through United States to western Europe.

(See Chart I-B). Anticyclonic circulation features characteristic of hot weather were very much in evidence this month and will be discussed in the following section on general circulation.

2. GENERAL CIRCULATION

Mean hemispheric circulation for June 1956 (fig. 1) exhibited several interesting features including: (1) An abnormally deep Low in the Arctic Basin. (2) A surrounding belt of high pressure containing three areas of maximum blocking activity, in northern Canada, northeastern Siberia, and northern Russia. (3) A strong subtropical high pressure belt, lying unusually far to the North, from mid-Pacific through the United States and central Atlantic. Added aspects of the last feature included a fast westerly 700-mb. jet stream displaced north of its normal location (figs. 2, 3), and unseasonably strong development of tropical easterlies (fig. 3).

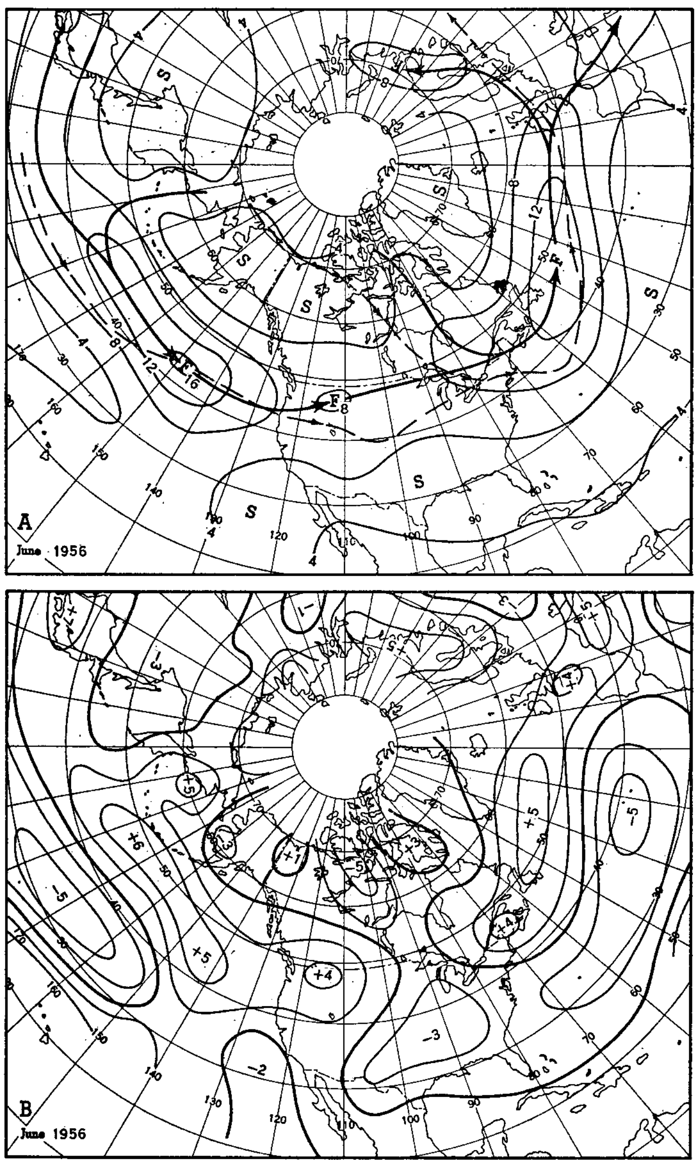


FIGURE 2.—(A) Mean 700-mb. isotachs and (B) departure from normal wind speed (both in meters per second) for June 1956. Solid arrows in (A) indicate axis of the mean jet stream at the 700-mb. level, which was north of its normal June position (dashed) in most sectors.

Fifteen-day mean maps for the month (fig. 4A and B) show how 700-mb. circulation features shifted from the first to the latter half-month. Significant transitions included filling of the west coast trough, collapse of the subtropical ridge over north central United States, and eastward motion of the east coast trough into the Atlantic. Also noteworthy were large 700-mb. height changes between the two halves of the month over Baffin Island (fig. 5), suggestive of a return toward the April blocking picture described by Dunn [2].

In describing the April-May 1956 circulation reversal, Klein [3] emphasized the poleward shift of several circulation features in May. The shift continued through June over the United States, as shown by figure 6, which gives successive mean monthly positions of the 700-mb. jet stream. The northward march was especially pronounced over western United States, where a well-marked zone of maximum westerlies replaced May's poorly defined wind field. Normally only a slight northward shift occurs from April to May.

Northward displacement of the subtropical anticyclone belt has been suggested by Namias and Dunn [4] as conducive to formation of tropical disturbances early in the season. A good example of northward displacement is seen in the 700-mb. height departure from normal field for June 1–15 (fig. 4A). Its suggested relationship to tropical activity can perhaps be further substantiated by the appearance of the season's first tropical storm in the Gulf of Mexico on June 13. Tropical storms are infrequent over the Gulf in June, this being only the second observed since 1946. The other was hurricane Alice in

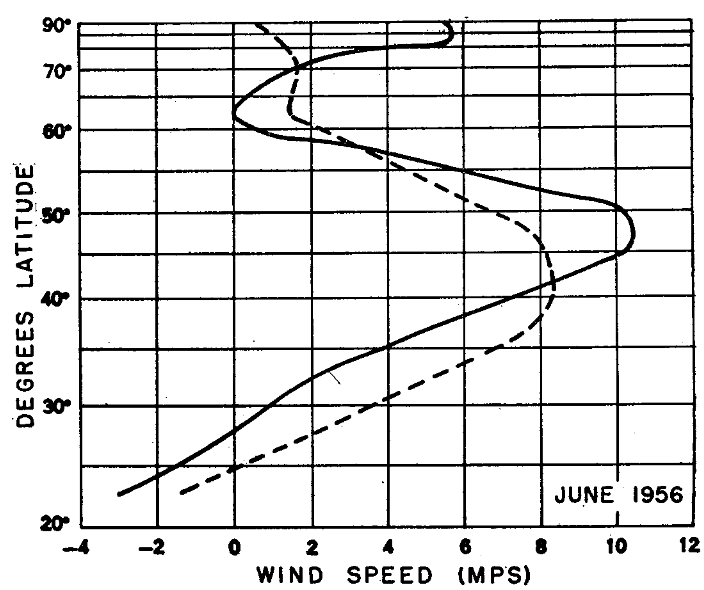


FIGURE 3.—Monthly mean zonal wind speed profiles for the Western Hemisphere at 700-mb. for June 1956 and June normal (dashed). Note northward displacement and intensification of the westerly maximum and stronger than normal subtropical easterlies (negative values).

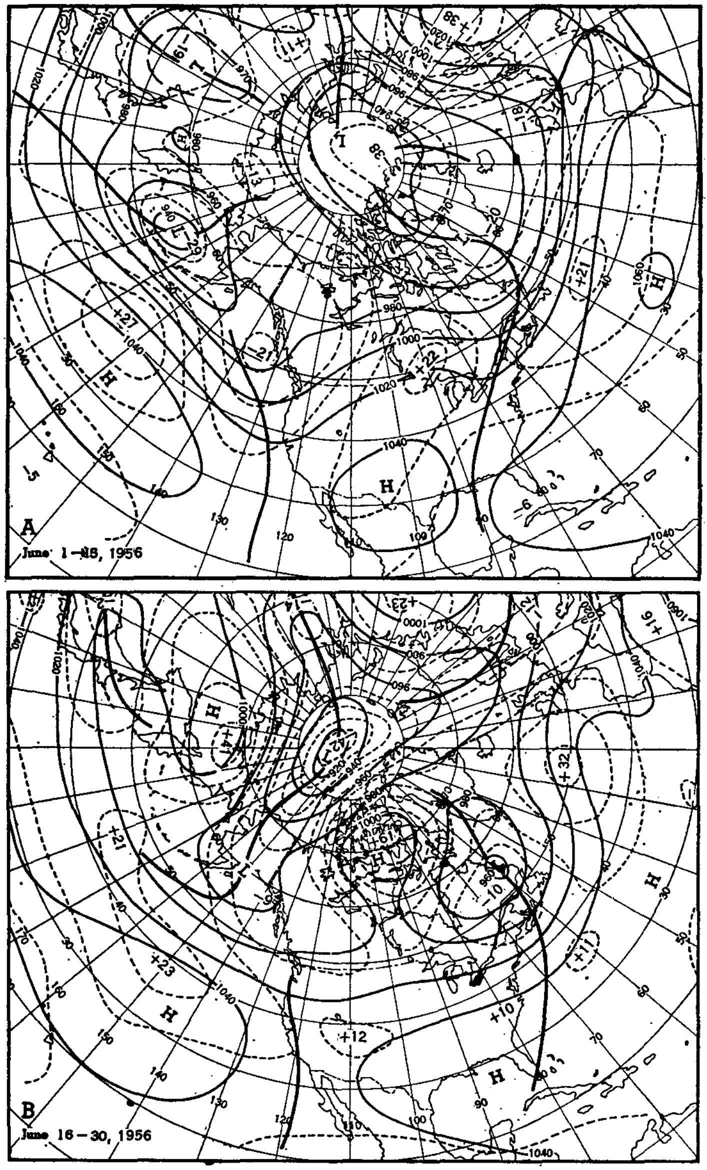


FIGURE 4.—15-day mean 700-mb. height contours and departures from normal (both in tens of feet) for (A) June 1–15, 1956 and (B) June 16–30, 1956. Large-amplitude ridge from Texas to Hudson Bay diminished as blocking set in over Baffin Island.

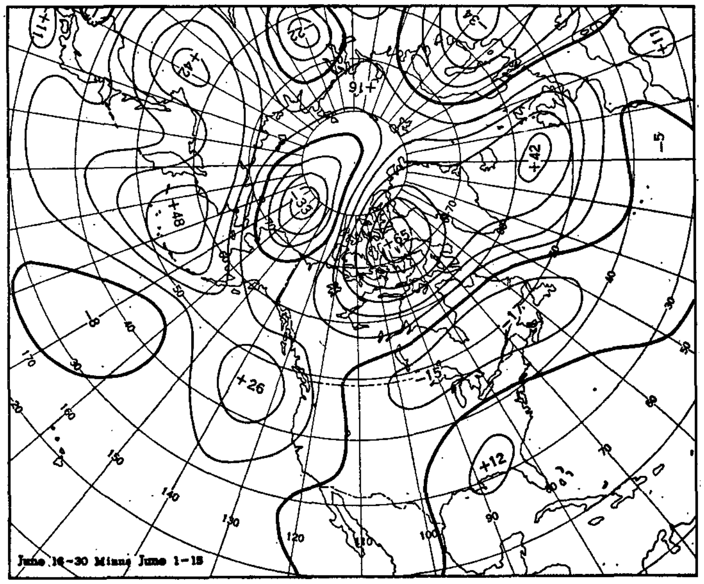


FIGURE 5.—Difference between 15-day mean 700-mb. contour heights for June 1–15 and June 16–30, 1956. Note large height increase over Baffin Island and decrease North Dakota to Newfoundland.

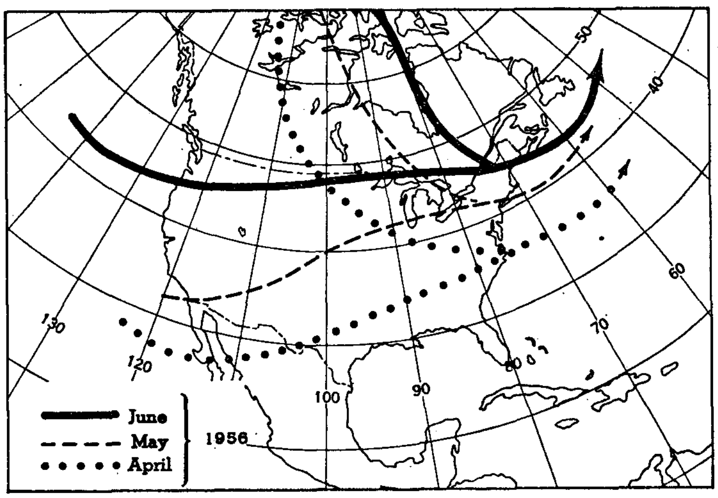


FIGURE 6.—Location of axes of jet streams on 700-mb. monthly mean charts, April 1956 (dotted), May 1956 (dashed) and June 1956 (solid). Note the pronounced northward progression from month to month.

1954, which entered the Gulf Coast south of Brownsville, Tex.

A series of 5-day mean 700-mb. maps (fig. 7) was chosen to represent the evolution of the circulation pattern during the formation and decay of this year's storm. The maps have much in common with a series of schematic charts used by Riehl [5] to illustrate a method for originating waves in easterly flow. He described the process as follows: In the first stage a large westerly trough extends well into the Tropics (fig. 7A), then the subtropical ridge moves northward and strengthens to cause wave fracture (fig. 7B). Riehl stated that the waves ordinarily weaken after fracture, with an exception when a cyclonic circulation forms in the easterly trough. Apparently this storm was an example of that exception.

A 5-day mean chart at the time of Hurricane Alice in June 1954 (fig. 6D of [1]) had a number of features in common with its counterpart (fig. 7B) in 1956. Both charts displayed wide separation between mean troughs off either coast at mid-latitudes (35°–40° N.) with a strong east-west subtropical ridge between them. Both subtropical ridge and tropical storm path were farther south, however, in 1954.

3. TEMPERATURE

Repeated injections of cool maritime air into the Pacific Northwest followed the increased westerly flow which accompanied changes in the circulation pattern from May to June. Seven Pacific fronts entered the country during the month of June, five of them extending

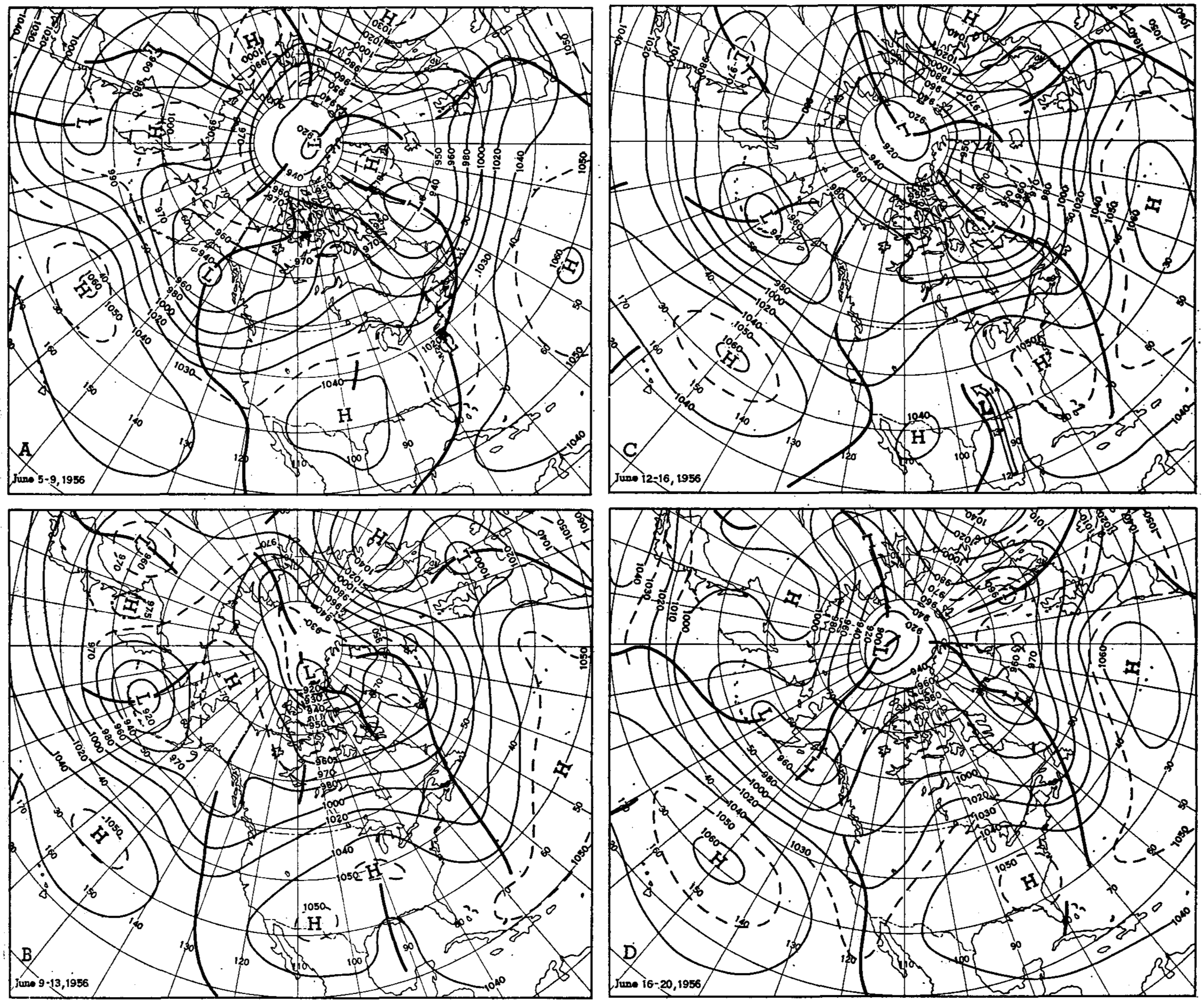


FIGURE 7.—Five-day mean 700-mb. height contours for (A) June 5–9, (B) June 9–13, (C) June 12–16, and (D) June 16–20, 1956. These charts show evolution of 5-day mean circulation during formation and decay of a small tropical storm in the Gulf of Mexico. Trajectory of this storm from the 12th to the 14th, given by the open arrow of (C), approximately paralleled the mean flow.

southward into California. Resulting cool temperatures (Chart I-B) marked a reversal from the May pattern over Washington and Oregon. An extreme change from much above to much below normal temperatures took place in eastern Washington.

Pacific air in strong westerly flow over the northern Rockies would be expected to lose much of its cool maritime character in descending the eastern slopes of the Continental Divide, and such was the case this month as evidenced by the temperature anomaly pattern (Chart I-B). Other factors contributing to the abnormal warmth east of the Divide were above normal height values (fig. 1) and anticyclonic relative vorticity (fig. 8) on the 700-mb. monthly mean map. Highest average June temperatures in 15 or more years were observed at a number of stations listed in table 1.

The heat was most extreme in the first half of June. During that period a pronounced 700-mb. height anomaly center near Lake Superior (+220 ft. in fig. 4A) was closely related to the temperature pattern. In a study of typical heat wave circulation patterns Klein [6] found close association between high values of 700-mb. height anomaly and sea level temperature. Klein's composite map (fig. 5 of [6]) for hottest 5-day mean temperatures at Kansas City during summer months bears a strong resemblance to the half-month mean map for June 1–15, 1956 (fig. 4A). Shifting most features of the composite map slightly northwestward into juxtaposition with those

TABLE 1.—*Stations reporting highest monthly mean temperatures for June since 1940*

Station	Mean temperature (° F.)	Last year with equal or higher average
Phoenix, Ariz	86.9	1940
Tucson, Ariz	86.2	1886
Denver, Colo	73.4	record*
Pueblo, Colo	76.3	record
Grand Junction, Colo	75.4	1940
Sioux City, Iowa	76.9	1933
Minneapolis-St. Paul, Minn	73.4	1933
Rochester, Minn	71.9	1934
Glasgow, Mont	67.6	1936
Havre, Mont	66.0	1936
North Platte, Nebr	74.0	1933
Albuquerque, N. Mex	78.9	record
Rapid City, S. Dak	72.8	record*
Cheyenne, Wyo	67.2	record
Sheridan, Wyo	67.2	1936

*Warmest June in 85 years of record at Denver and 65 years at Rapid City.

of figure 4A helps explain the temperature anomaly pattern observed from June 3–17, 1956 (fig. 9A and B). An article by McQueen and Shellum [7] in this issue describes in greater detail the major heat wave June 9–13. Table 2 of their article lists many stations with record temperatures for those days.

Warming advanced eastward from June 10 to June 17 across northern United States into New York, Pennsylvania, and New England (fig. 9). Table 2 lists some new daily records downstream from the major heat wave area. While only two of the original seven Pacific fronts survived to reach the Atlantic Coast, others were strong enough to induce outbreaks of continental polar air and cause large short-period temperature fluctuations across northeastern United States. The strongest of these outbreaks into the Northeast came around the 20th and again at month's end as the subtropical ridge gave way and the block increased over eastern Canada.

Early in June a strong frontal system brought record-breaking cool air into most of the country east of the Mississippi Valley (See table 3). Cool temperatures persisted in the Southeast behind a strong east coast trough until the trough showed signs of fracture on June 10 (fig. 9A). Thereafter, cooling shifted westward with the easterly portion of the trough. Cloudiness and precipitation in the trough and its associated tropical storm persisted for several days. Temperatures over all the Gulf States as well as Arkansas and parts of Oklahoma, Missouri, and Tennessee were affected by this relatively weak storm (fig. 9B).

TABLE 2.—*Daily record high temperatures occurring in the East after the major heat wave in the Midwest, June 9–13, 1956.*

Date	Place	Temperature (°F.)
14	Newark, N. J	99
14	Trenton, N. J	96
14	Syracuse, N. Y	92
14	Reading, Pa	96
14	Scranton, Pa	92
14	Providence, R. I	92
15	Syracuse, N. Y	92
15	Richmond, Va	96
16	Nantucket, Mass	87

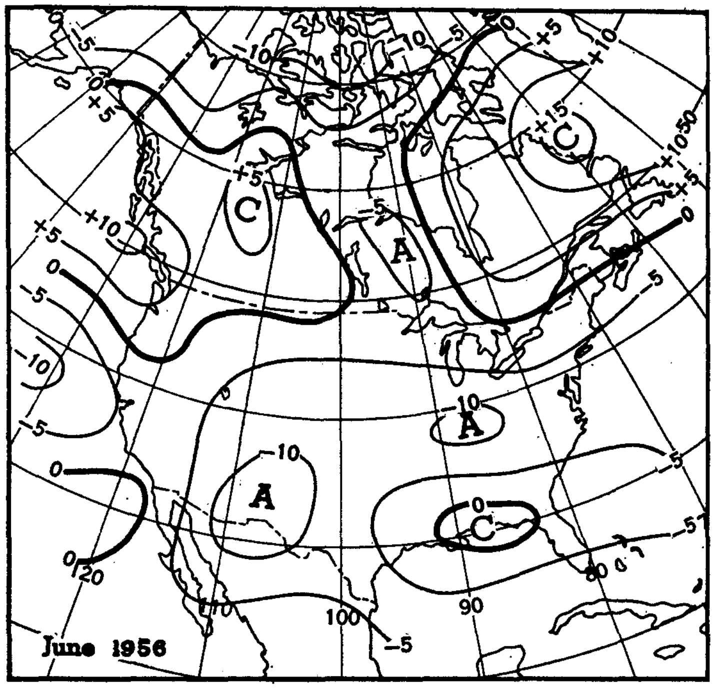


FIGURE 8.—Vertical component of the mean geostrophic vorticity at 700-mb. for June 1956, in units of 10^{-6} sec.$^{-1}$. Cyclonic vorticity and anticyclonic vorticity are considered positive and negative respectively and labeled C and A at centers. Note dominance of anticyclonic vorticity in the heat wave zone in central United States.

Temperatures were warm under anticyclonic circulation in the Southwest. Over Arizona, circulation changes from May were small, and persistence favored high monthly average temperatures, some of which are found in table 1.

4. PRECIPITATION

Precipitation presented a complex picture this month and its pattern, unlike that of temperature, could not all be fitted in neatly with monthly mean circulation. Factors combining to produce excess rainfall in the Pacific Northwest were a stronger than normal mean trough (fig. 1), especially in the first half-month (fig. 4A), and stronger than normal mean westerly flow (fig. 2) ascending over higher terrain. As the west coast trough shifted eastward at mid-month (fig. 7C), a frontal Low formed near Great Salt Lake (Chart X). This Low caused abundant rainfall as it moved northward, especially in northwestern Montana. Most of the rainfall from North

TABLE 3.—*New all-time record low temperatures for the month, established in June 1956.*

Date	Place	Temperature (°F.)
2	Evansville, Ind	45
2	Grand Rapids, Mich	35
2	Green Bay, Wis	33
3	Birmingham, Ala	46
3	Apalachicola, Fla	58
3	Columbus, Ga	44
3	Meridian, Miss	45
5	Burns, Oreg	28

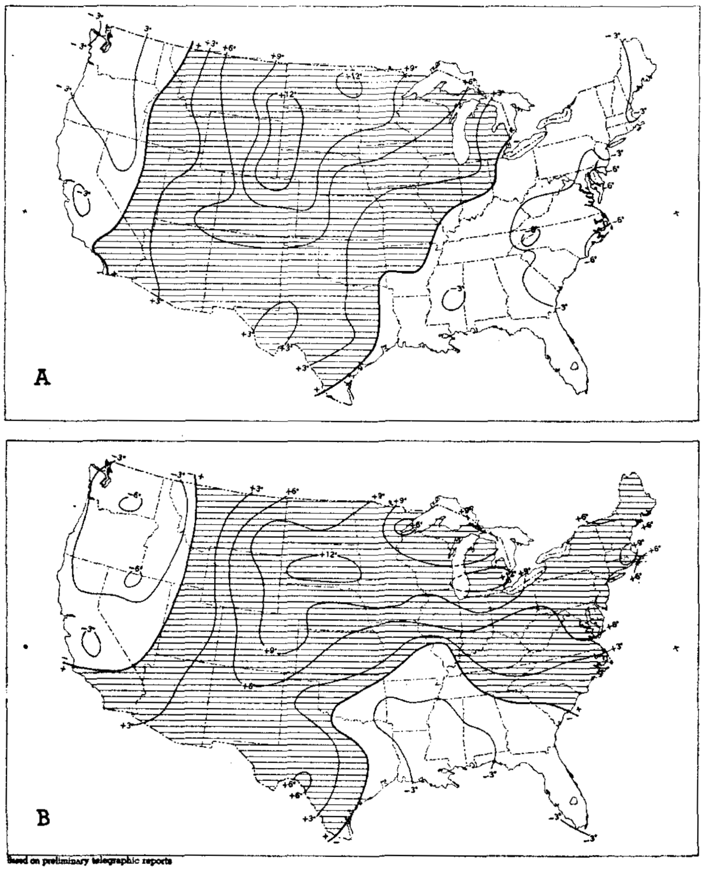


FIGURE 9.—Departure of average temperature from normal for the week ending midnight (A) June 10, 1956, and (B) June 17, 1956. Note warming in the Northeast and westward progression of cooling in the South. (From *Weekly Weather and Crop Bulletin, National Summary,* vol. XLIII, Nos. 24 and 25, June 11 and 18, 1956.)

Dakota to Pennsylvania came as showers, mainly frontal in nature.

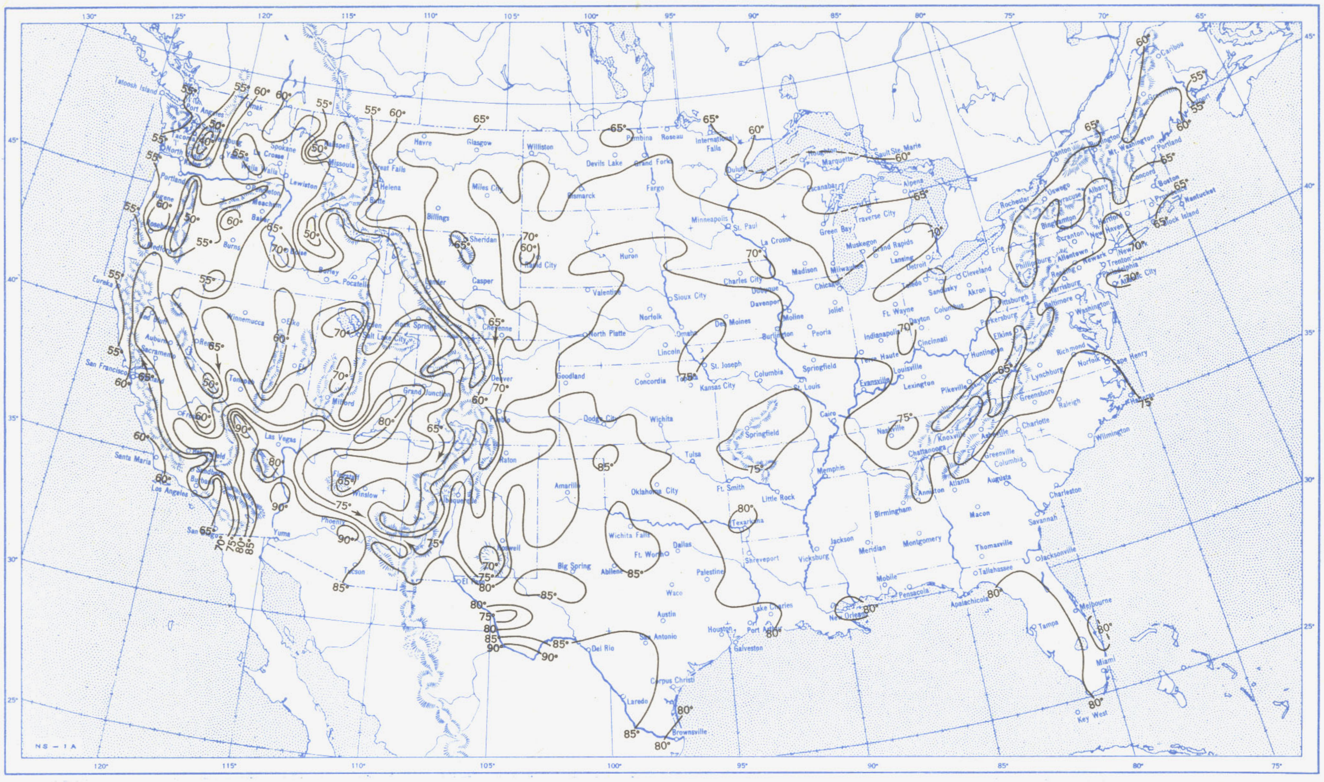
Frontal waves in early June added much to east coast totals, and net easterly 700-mb. departure from normal flow (fig. 4A) made a further contribution along the South Atlantic Coast. A finger of heavy precipitation (Chart III) protruding from the Gulf Coast to Arkansas was associated with the tropical storm (see track fig. 7C). Despite its small size and fairly weak winds (strongest, 45 m. p. h. at New Orleans, La., Airport), the storm dumped 3 to 9 inches of rain over southern sections of Louisiana, Mississippi, and Alabama to break developing drought conditions in the middle Cotton Belt.

Central Texas remained dry, with Abilene recording only 0.12 inch to bring the May-June total up to only 0.27. It was also dry in Arizona, where not even a trace was recorded at 5 reporting stations between the 4th and the 27th. However, substantial amounts fell thereafter over the eastern three-quarters of the State. Showers also increased over western Texas and New Mexico as strongly anticyclonic conditions relaxed during the latter half-month.

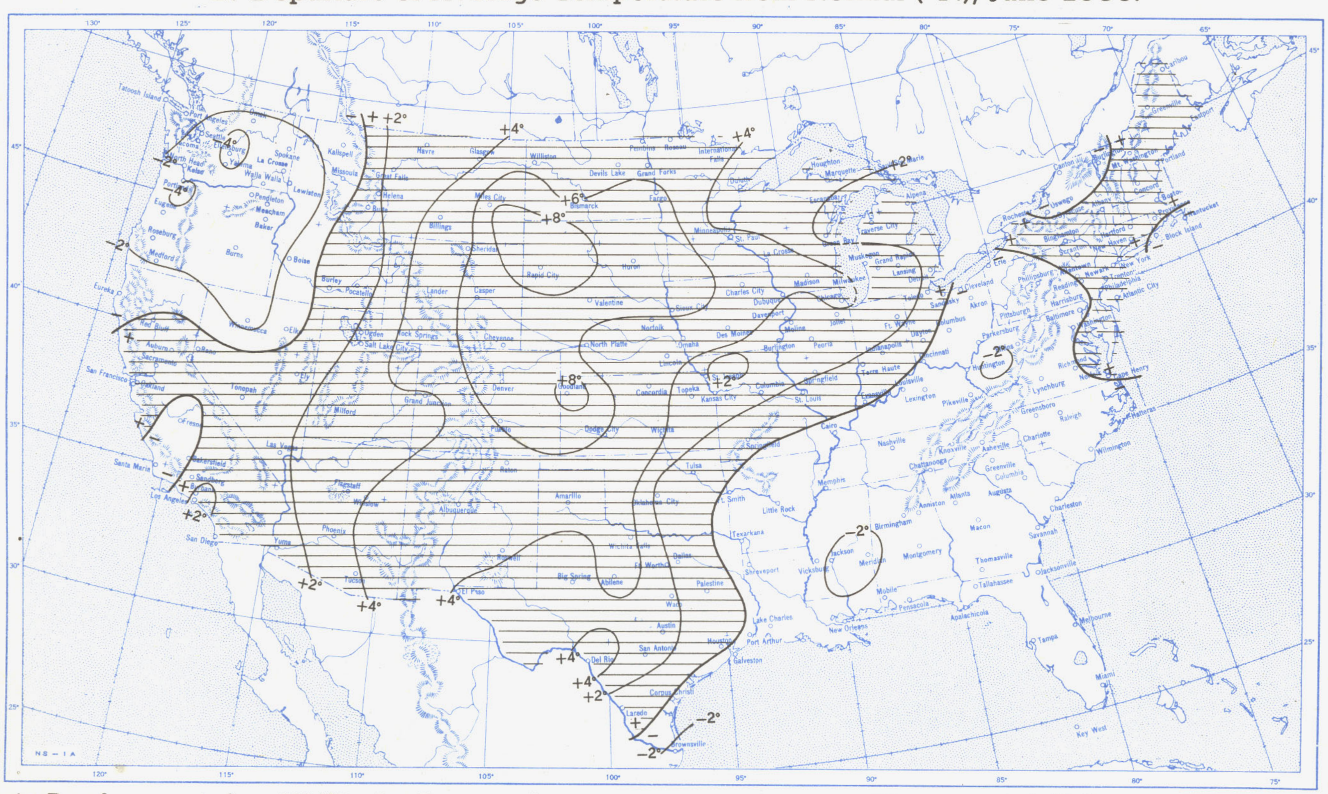
REFERENCES

1. J. Z. Holland, "The Weather and Circulation of June, 1954—Illustrating the Birth and Growth of a Continental Anticyclone", *Monthly Weather Review,* vol. 82, No. 6, June 1954, pp. 163–171.
2. C. R. Dunn, "The Weather and Circulation of April 1956—A Cold Month With a Retrograding, Blocking Surge", *Monthly Weather Review,* vol. 84, No. 4, April 1956, pp. 146–154.
3. W. H. Klein, "The Weather and Circulation of May 1956—Another April-May Reversal", *Monthly Weather Review,* vol. 84, No. 6, May 1956, pp. 190–197.
4. J. Namias and C. R. Dunn, "The Weather and Circulation of August 1955—Including the Climatological Background for Hurricanes Connie and Diane", *Monthly Weather Review,* vol. 83, No. 8, August 1955, pp. 163–170.
5. H. Riehl, *Tropical Meteorology,* McGraw-Hill, Inc., 1954, pp. 226–227.
6. W. H. Klein, "The Weather and Circulation of June 1952—A Month With a Record Heat Wave", *Monthly Weather Review,* vol. 80, No. 6, June 1952, pp. 99–104.
7. H. R. McQueen and H. J. Shellum, "The Heat Wave from the Intermountain Area to the Northern Great Lakes, June 9–13, 1956", *Monthly Weather Review,* vol. 84, No. 6, June 1956, pp. 242–251.

Chart I. A. Average Temperature (°F.) at Surface, June 1956.

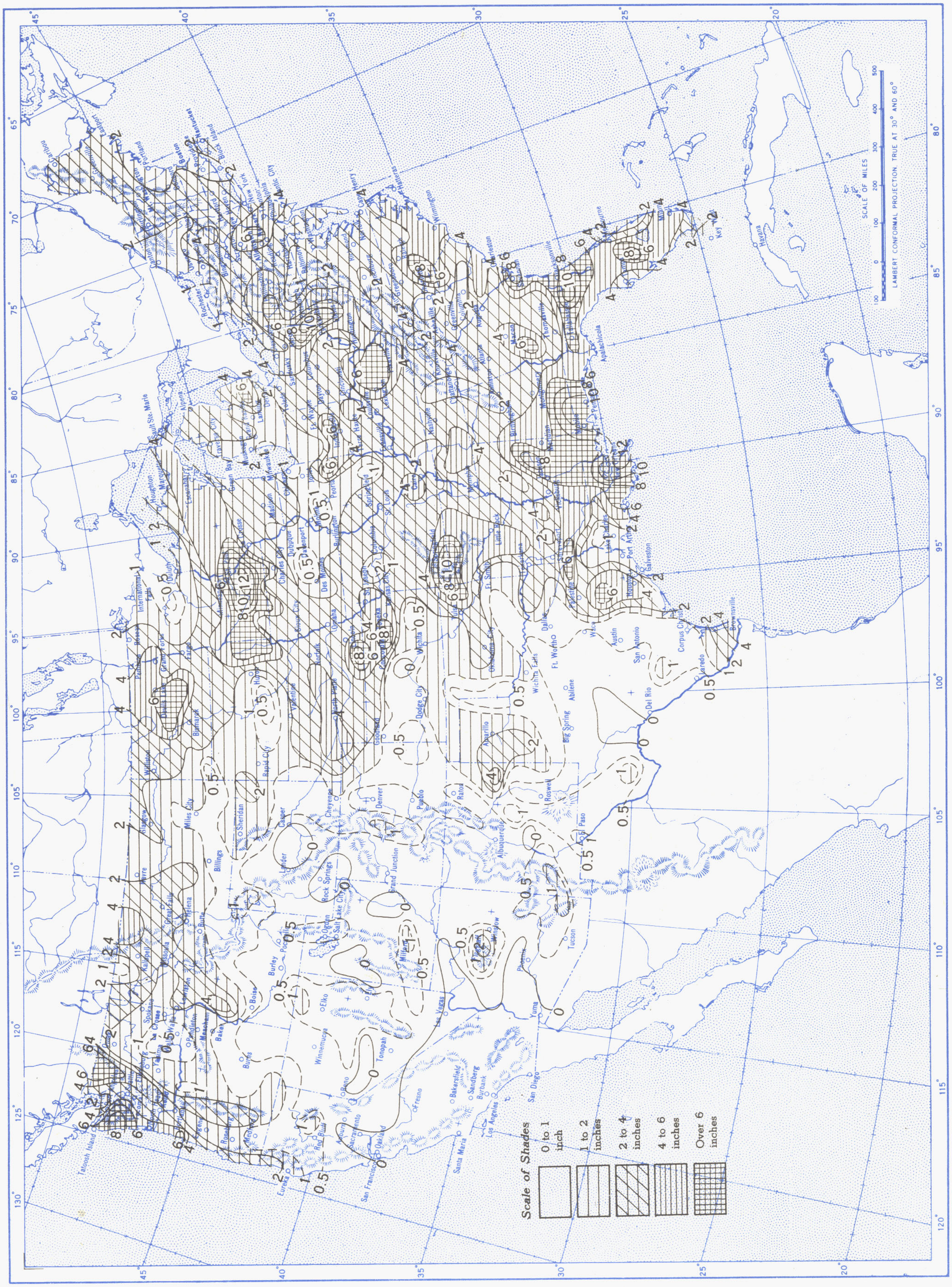


B. Departure of Average Temperature from Normal (°F.), June 1956.



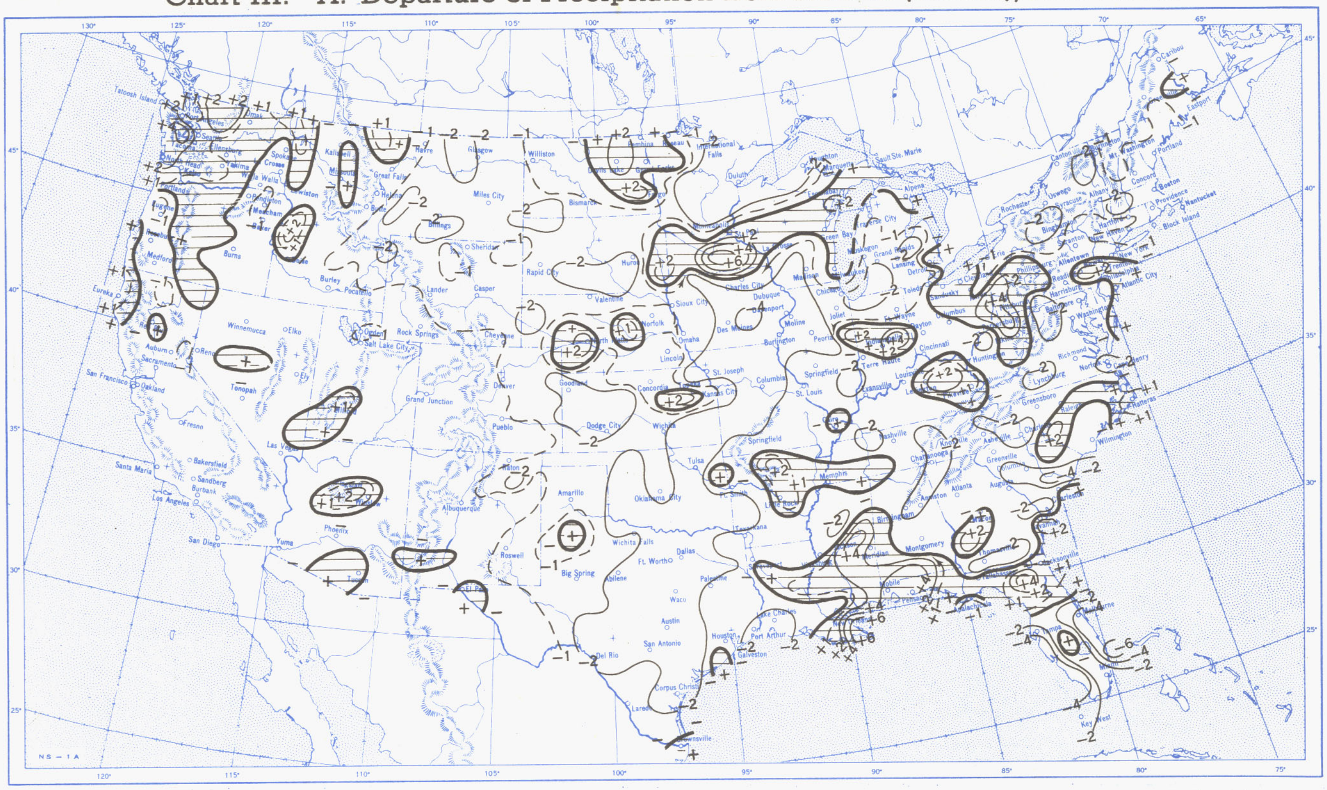
A. Based on reports from 800 Weather Bureau and cooperative stations. The monthly average is half the sum of the monthly average maximum and monthly average minimum, which are the average of the daily maxima and daily minima, respectively.
B. Normal average monthly temperatures are computed for Weather Bureau stations having at least 10 years of record.

Chart II. Total Precipitation (Inches), June 1956.

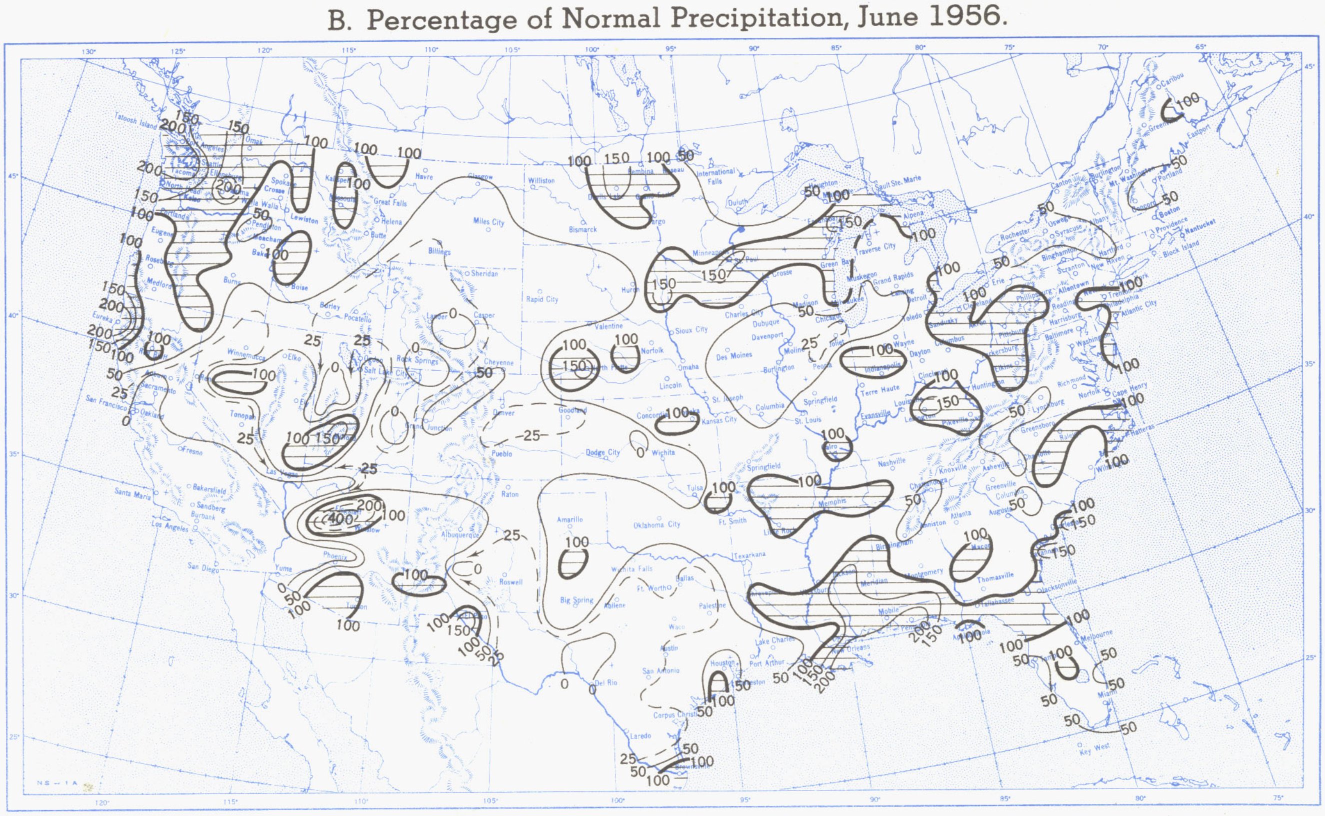


Based on daily precipitation records at 800 Weather Bureau and cooperative stations.

Chart III. A. Departure of Precipitation from Normal (Inches), June 1956.

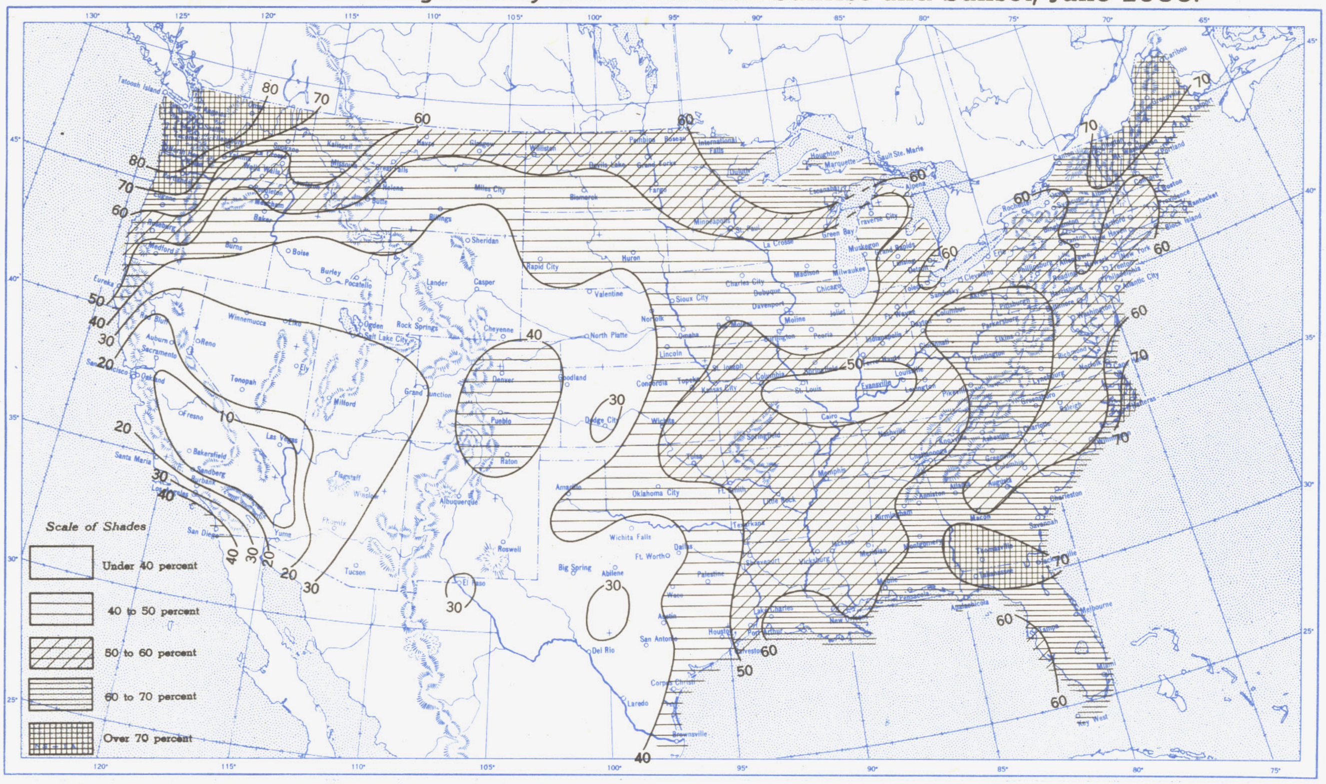


B. Percentage of Normal Precipitation, June 1956.

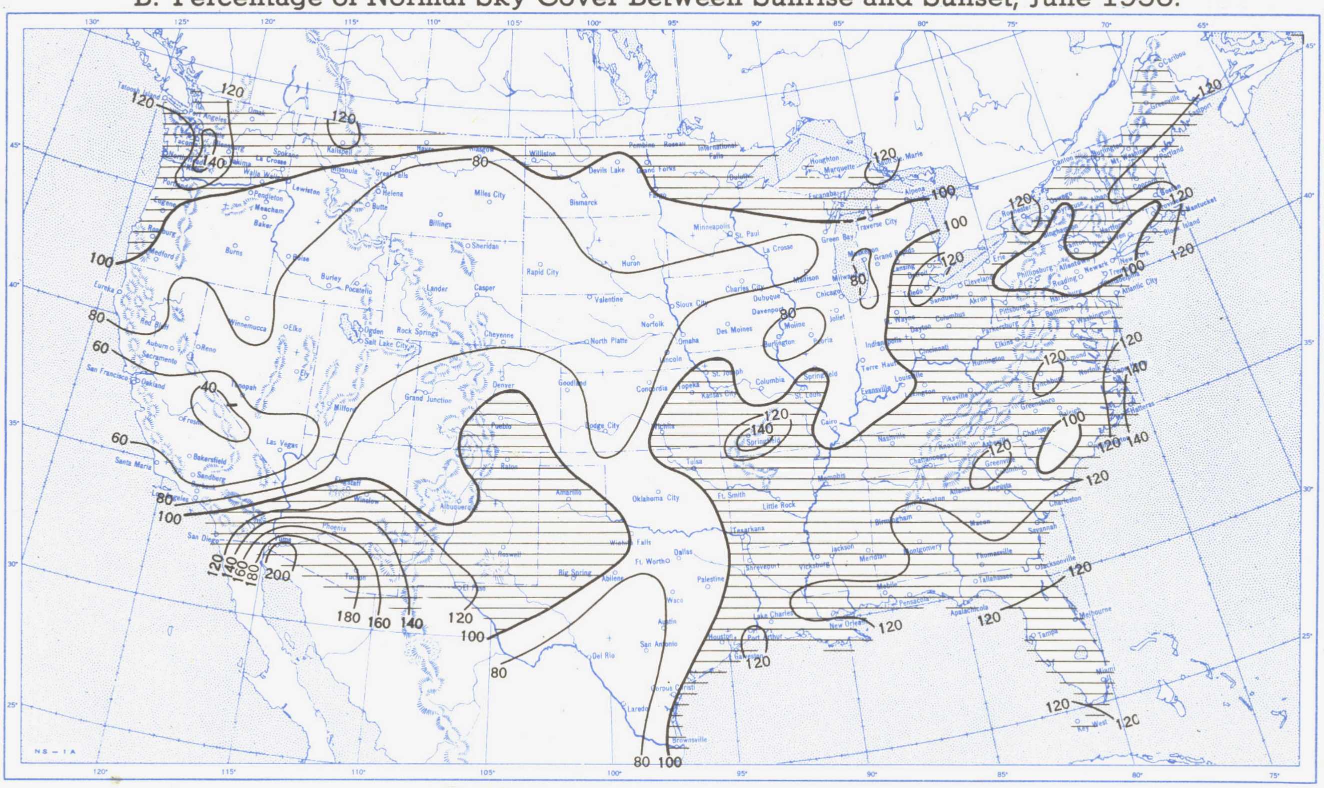


Normal monthly precipitation amounts are computed for stations having at least 10 years of record.

Chart VI. A. Percentage of Sky Cover Between Sunrise and Sunset, June 1956.



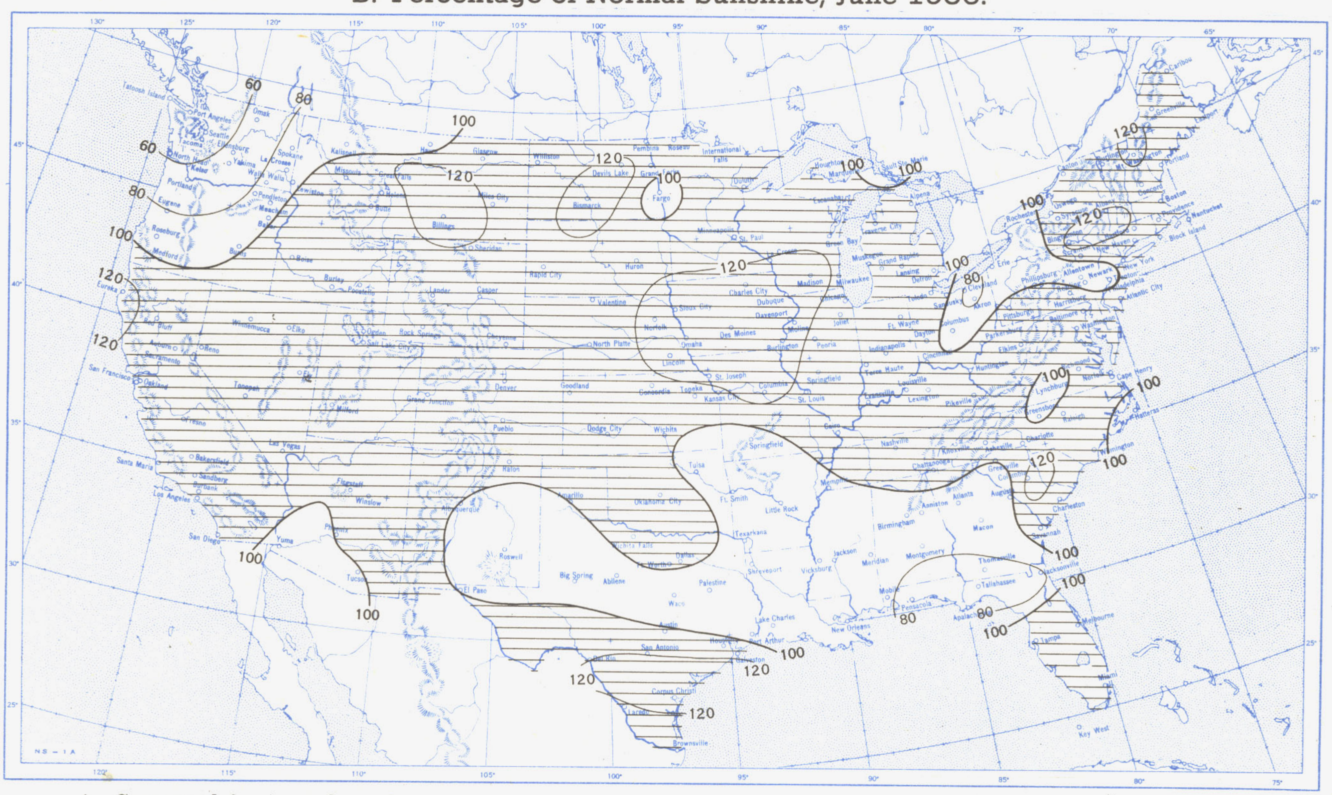
B. Percentage of Normal Sky Cover Between Sunrise and Sunset, June 1956.



A. In addition to cloudiness, sky cover includes obscuration of the sky by fog, smoke, snow, etc. Chart based on visual observations made hourly at Weather Bureau stations and averaged over the month. B. Computations of normal amount of sky cover are made for stations having at least 10 years of record.

Chart VII. A. Percentage of Possible Sunshine, June 1956.

B. Percentage of Normal Sunshine, June 1956.



A. Computed from total number of hours of observed sunshine in relation to total number of possible hours of sunshine during month. B. Normals are computed for stations having at least 10 years of record.

Chart VIII. Average Daily Values of Solar Radiation, Direct + Diffuse, June 1956. Inset: Percentage of Mean Daily Solar Radiation, June 1956. (Mean based on period 1951-55.)

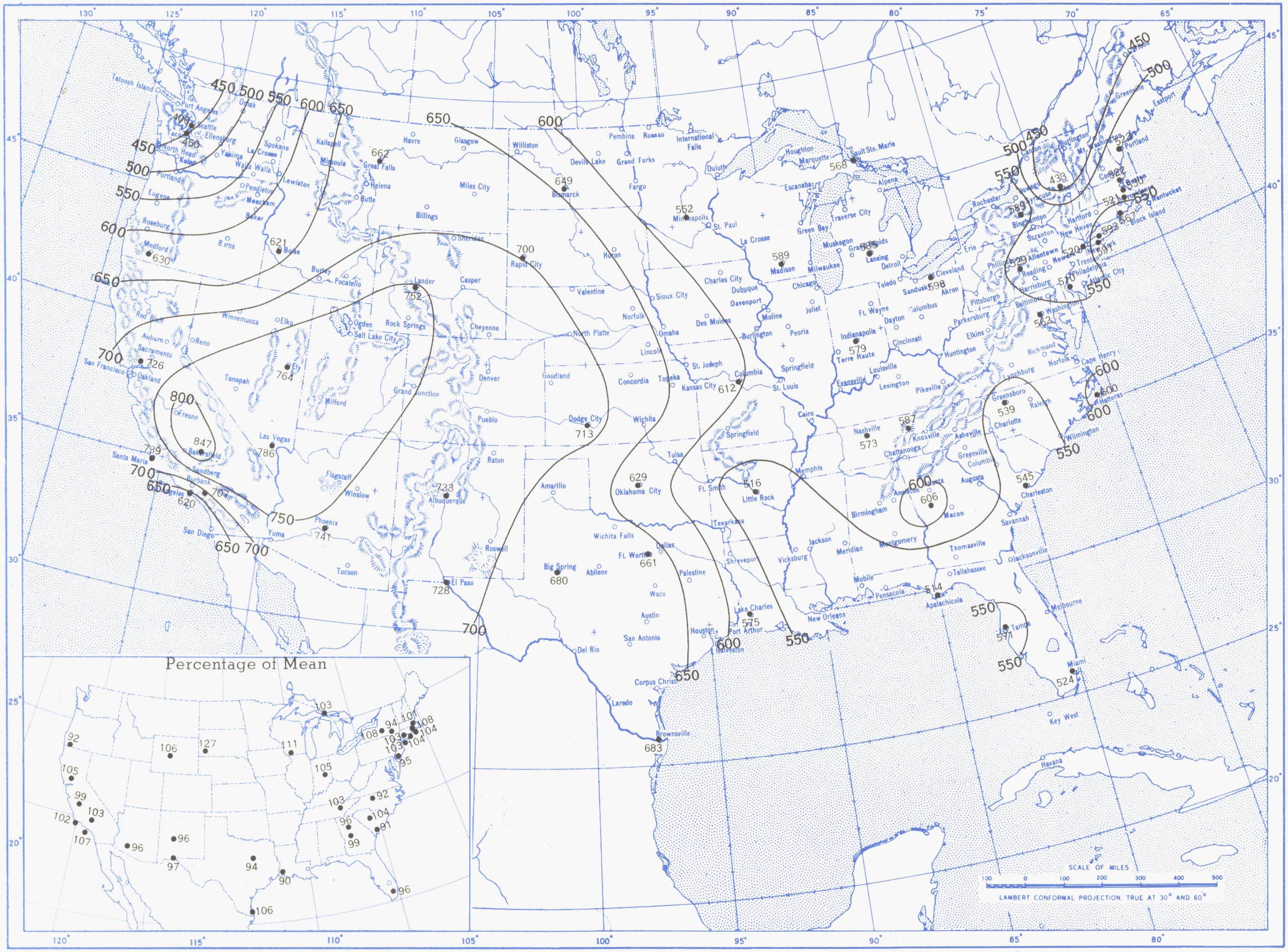
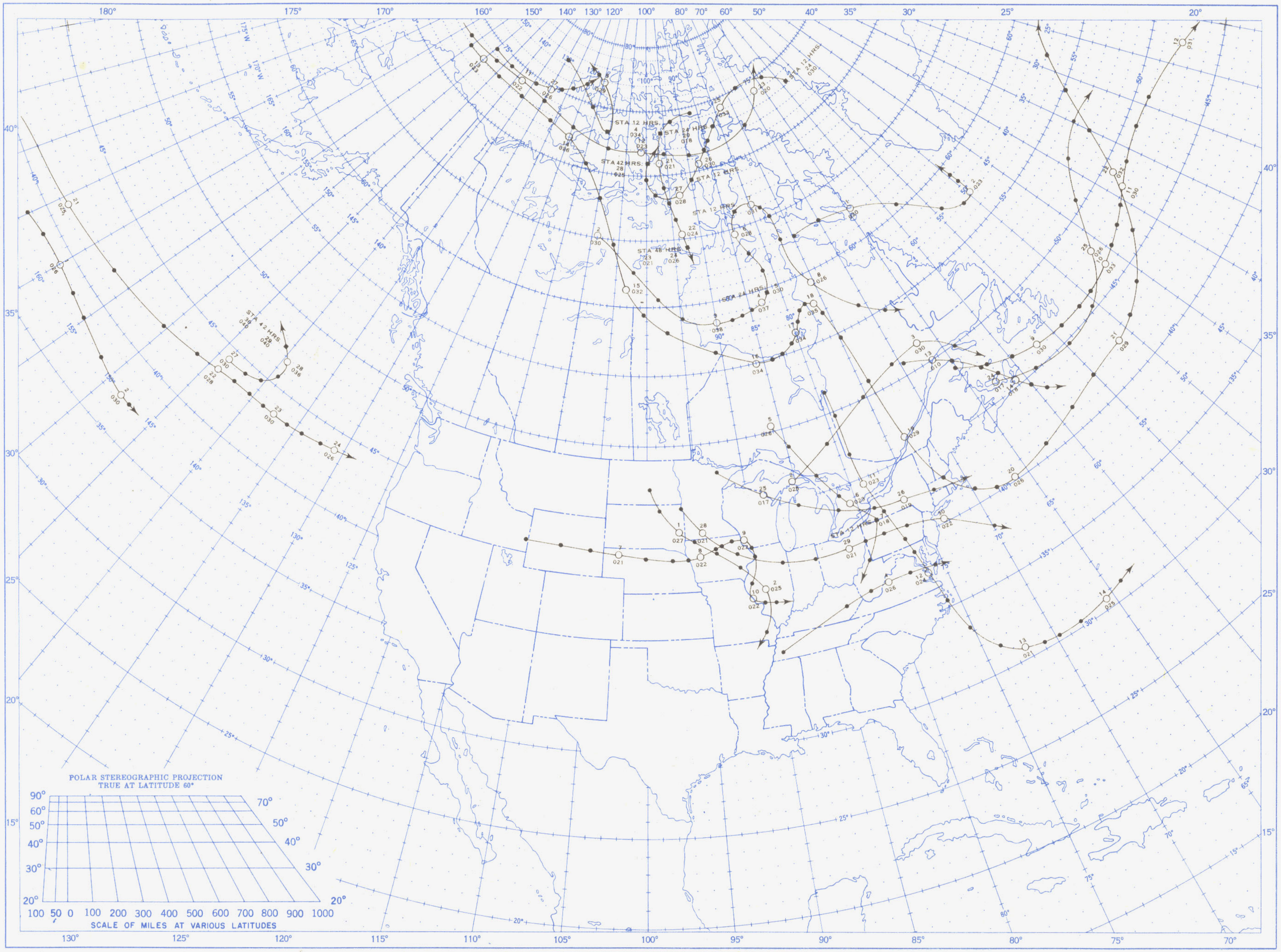


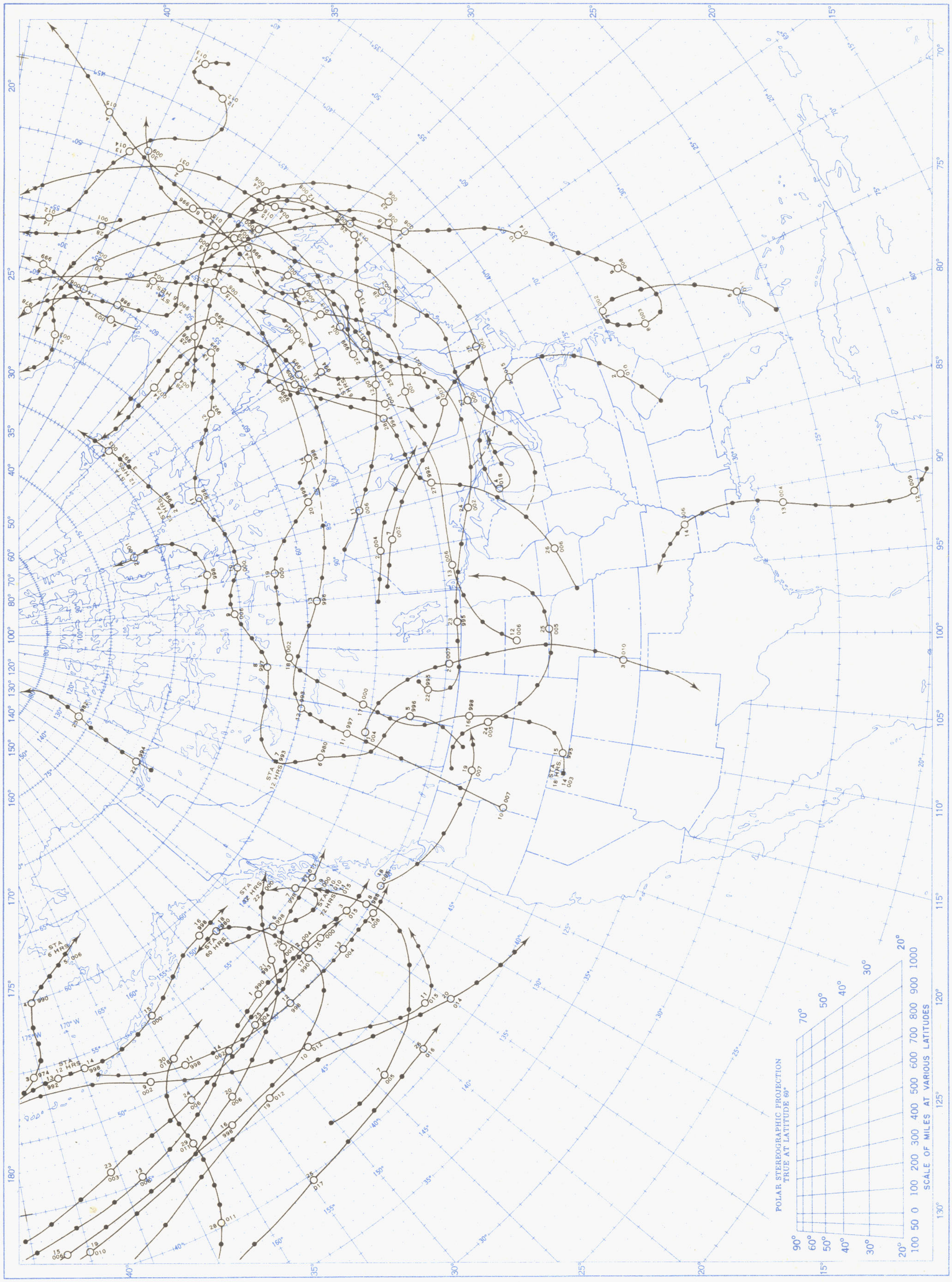
Chart shows mean daily solar radiation, direct + diffuse, received on a horizontal surface in langleys (1 langley = 1 gm. cal. cm. $^{-2}$). Basic data for isolines are shown on chart. Further estimates are obtained from supplementary data for which limits of accuracy are wider than for those data shown.

Chart IX. Tracks of Centers of Anticyclones at Sea Level, June 1956.



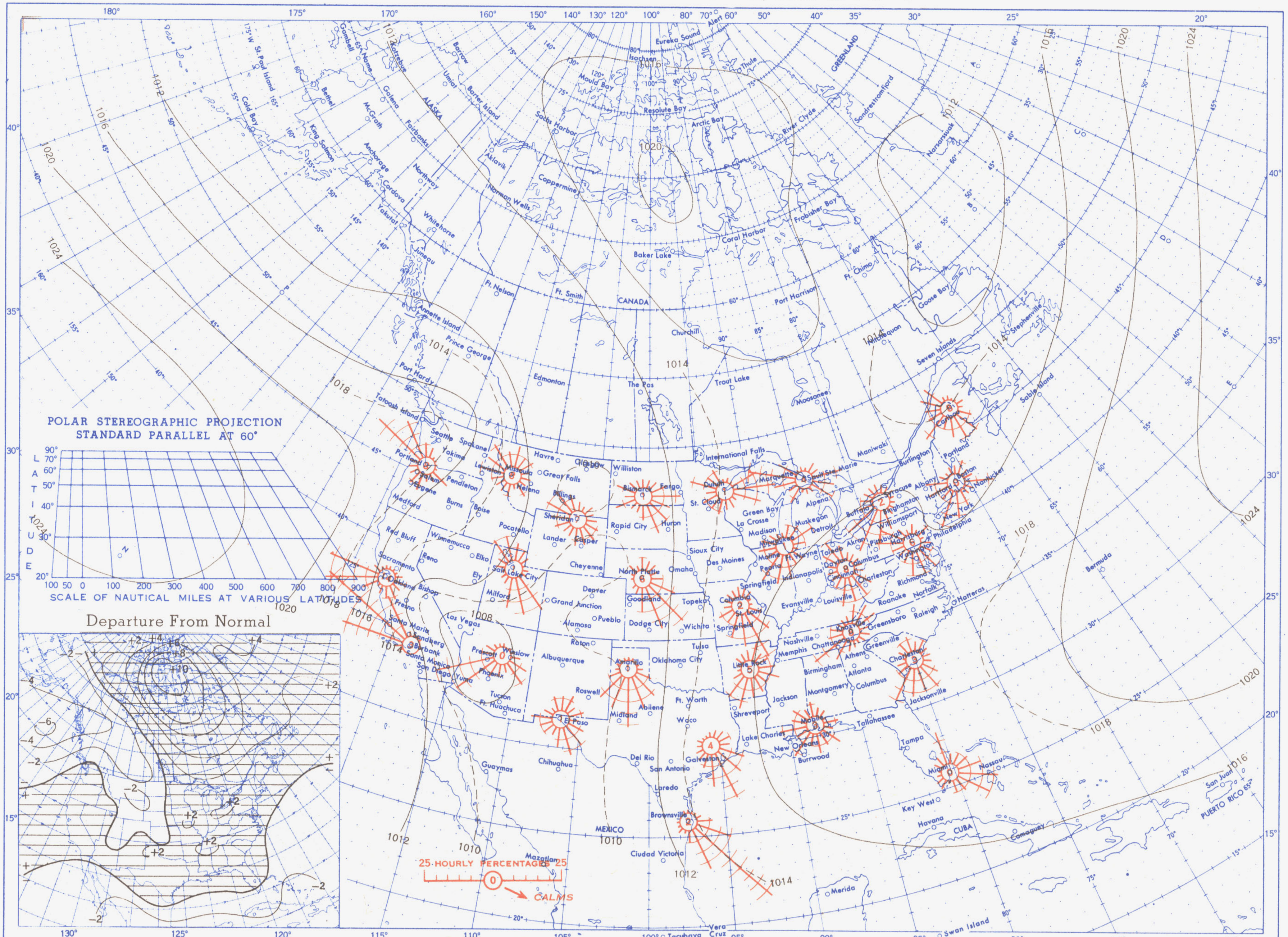
Circle indicates position of center at 7:30 a. m. E. S. T. Figure above circle indicates date, figure below, pressure to nearest millibar. Dots indicate intervening 6-hourly positions. Squares indicate position of stationary center for period shown. Dashed line in track indicates reformation at new position. Only those centers which could be identified for 24 hours or more are included.

Chart X. Tracks of Centers of Cyclones at Sea Level, June 1956.



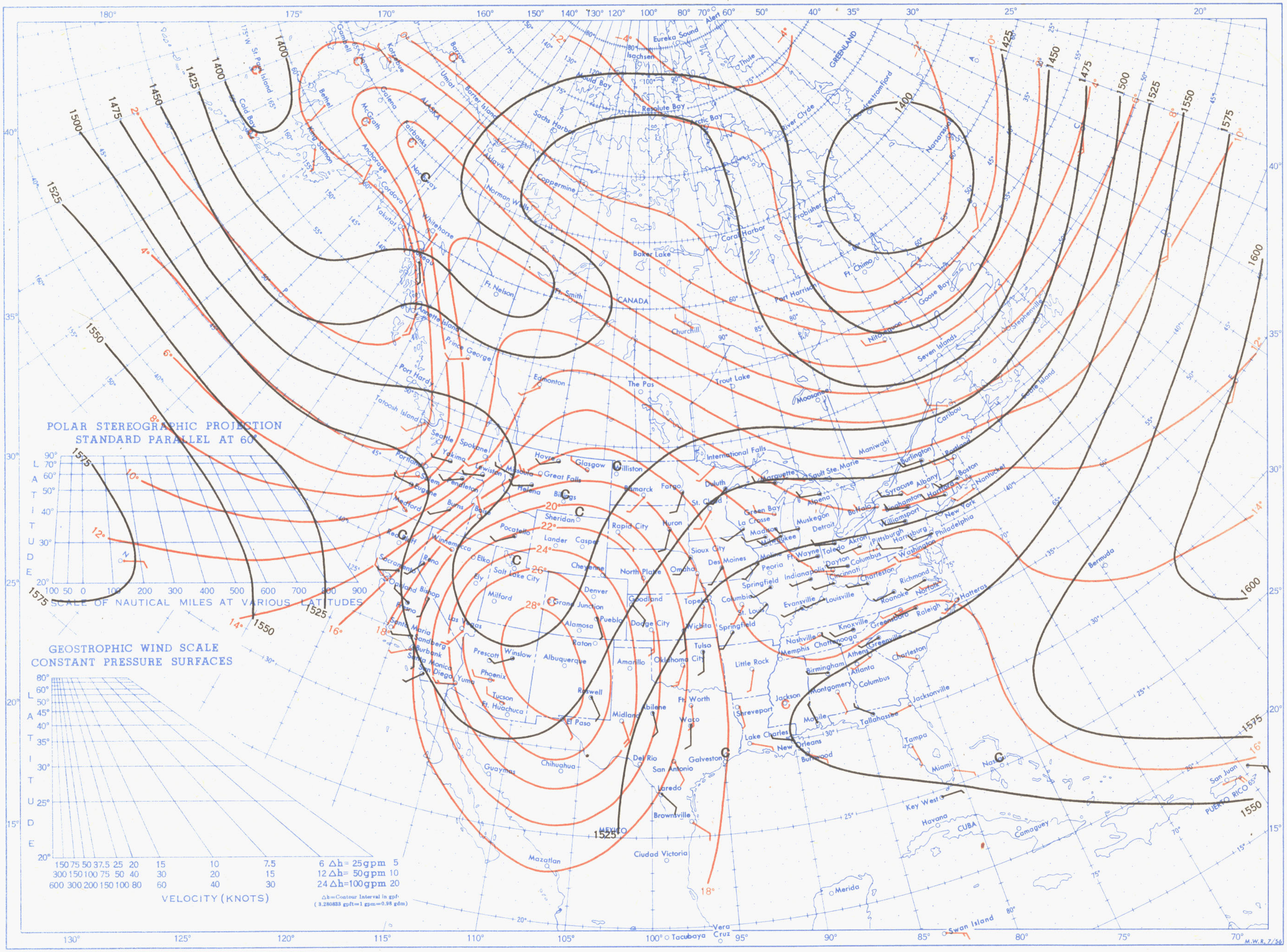
Circle indicates position of center at 7:30 a. m. E. S. T. See Chart IX for explanation of symbols.

Chart XI. Average Sea Level Pressure (mb.) and Surface Windroses, June 1956. Inset: Departure of Average Pressure (mb.) from Normal, June 1956.



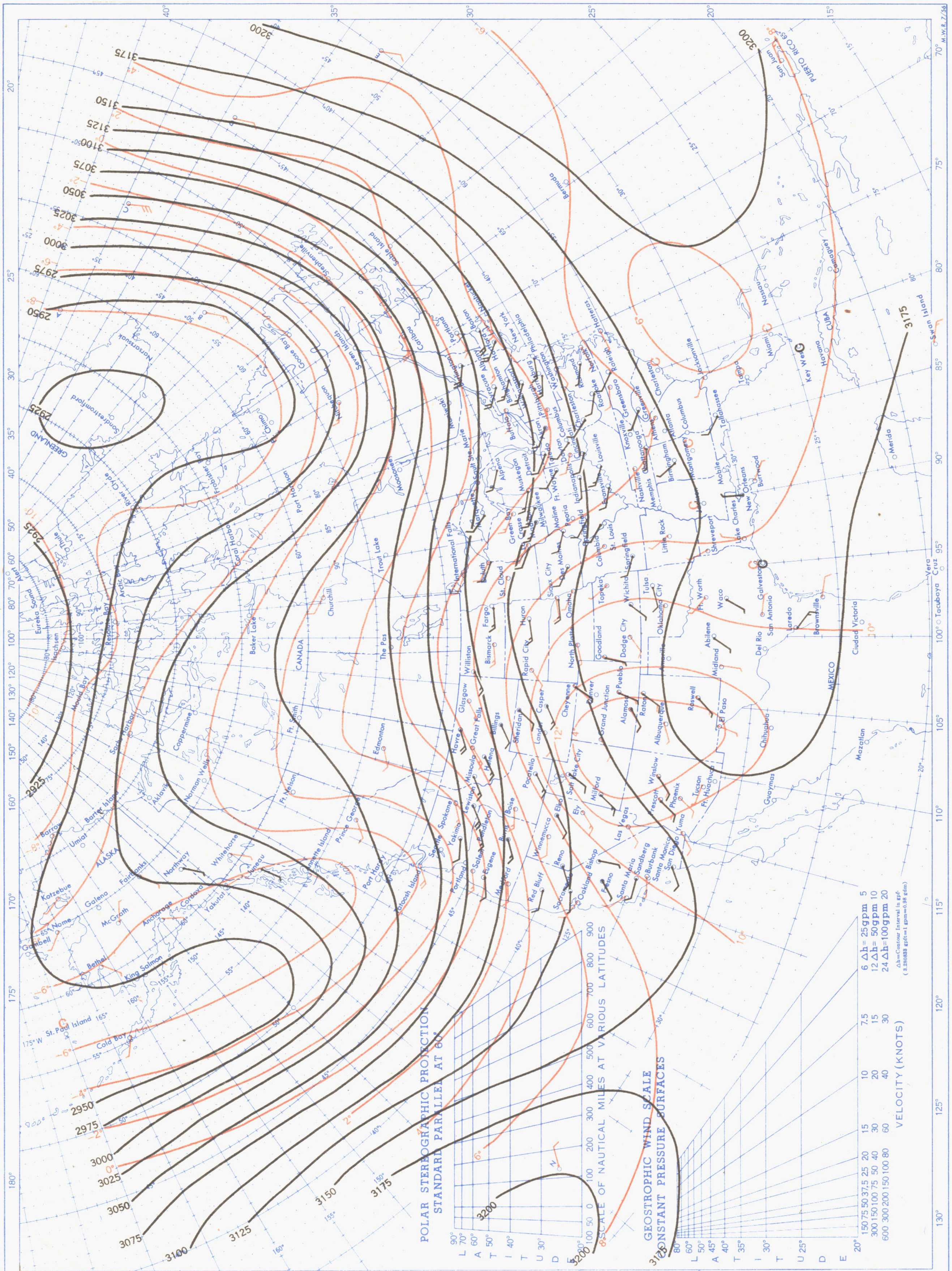
Average sea level pressures are obtained from the averages of the 7:30 a. m. and 7:30 p. m. E. S. T. readings. Windroses show percentage of time wind blew from 16 compass points or was calm during the month. Pressure normals are computed for stations having at least 10 years of record and for 10° intersections in a diamond grid based on readings from the Historical Weather Maps (1899-1939) for the 20 years of most complete data coverage prior to 1940.

Chart XII. 850-mb. Surface, 0300 GMT, June 1956. Average Height and Temperature, and Resultant Winds.



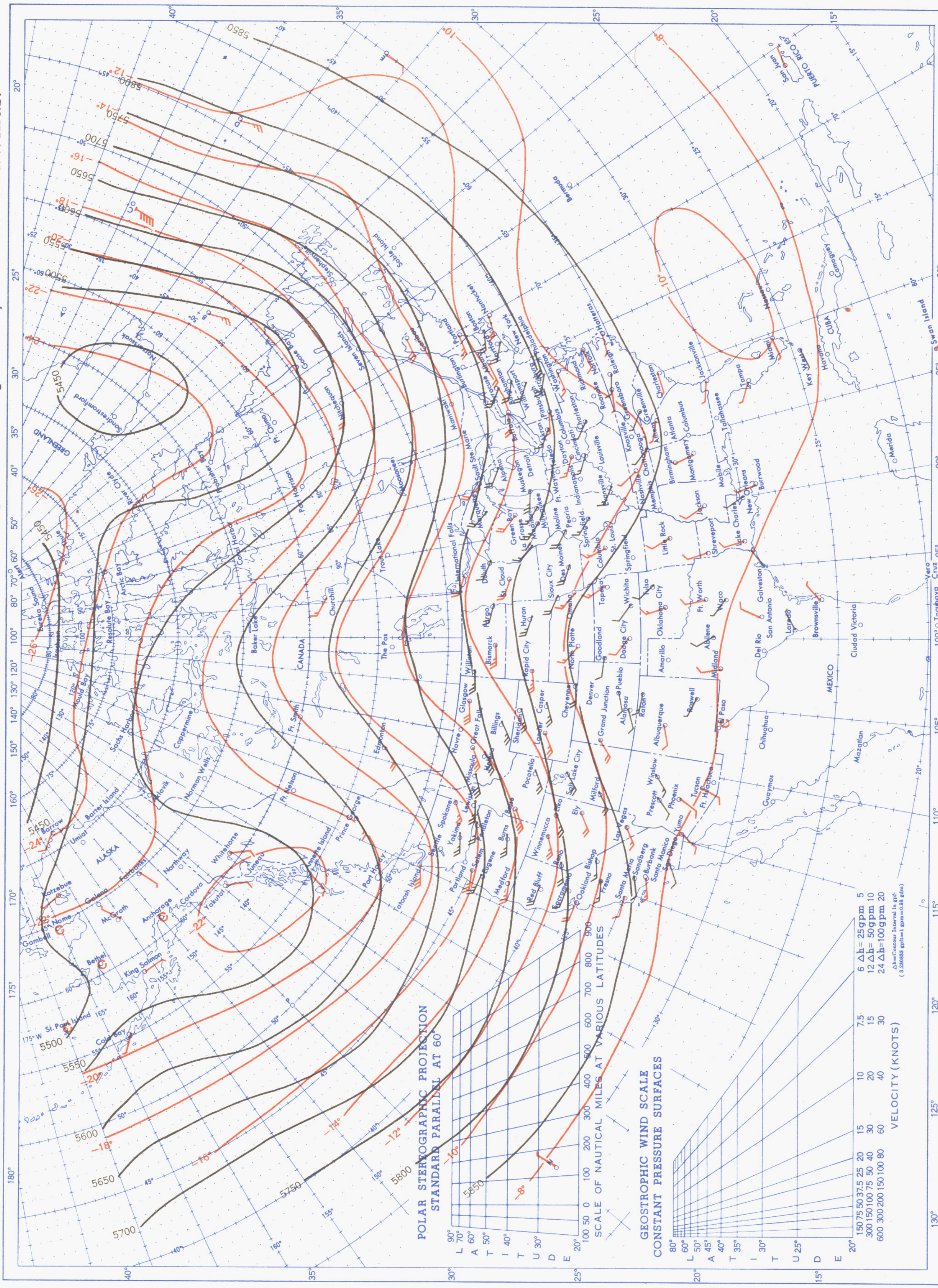
Height in geopotential meters (1 g.p.m. = 0.98 dynamic meters). Temperature in °C. Wind speed in knots; flag represents 50 knots, full feather 10 knots, and half feather 5 knots. Winds shown in red are based on rawins taken at the indicated pressure surface and time. Those in black are based on pibals taken at 2100 GMT and are for the nearest standard height level.

Chart XIII. 700-mb. Surface, 0300 GMT, June 1956. Average Height and Temperature, and Resultant Winds.



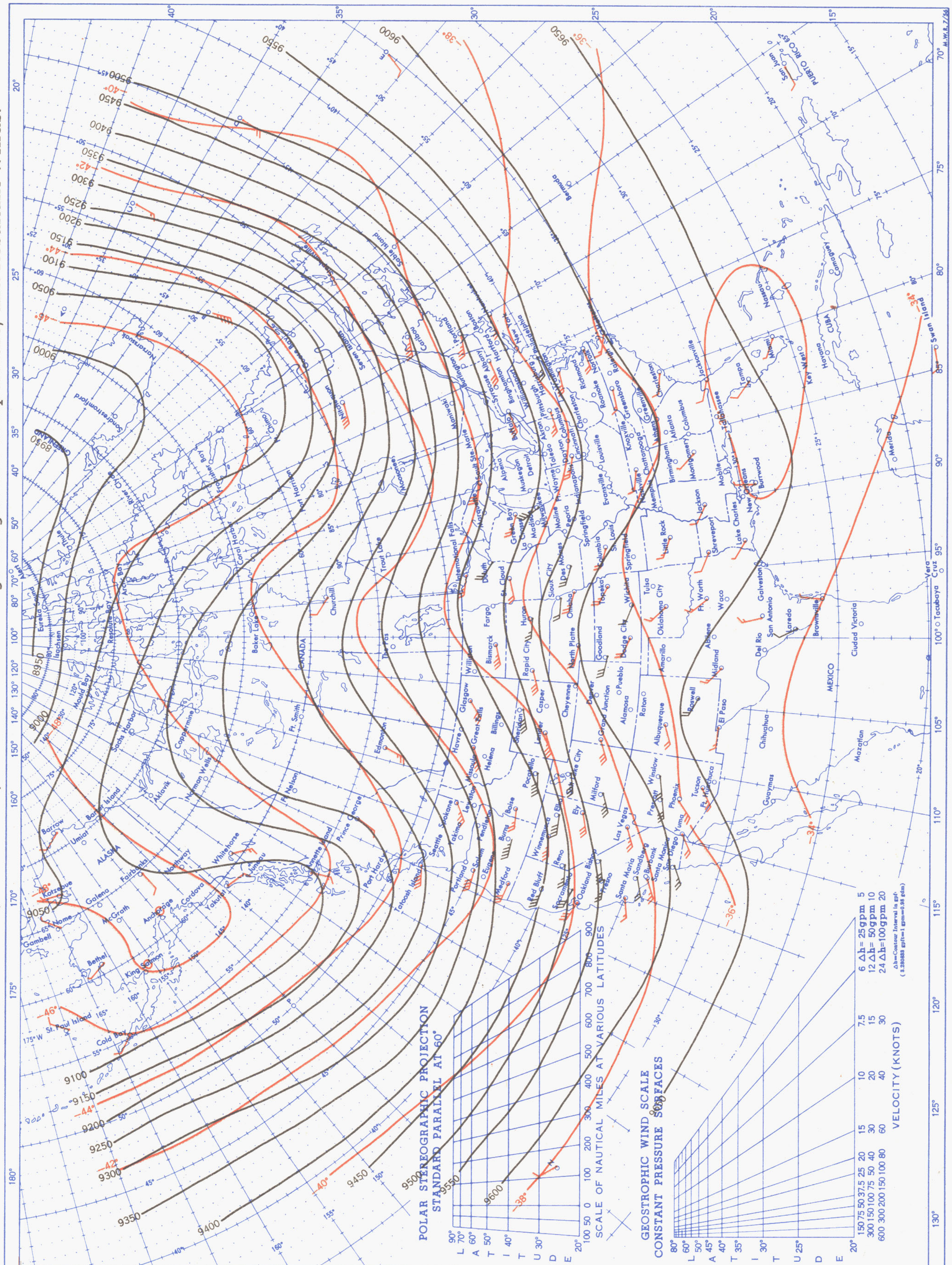
See Chart XII for explanation of map.

Chart XIV. 500-mb. Surface, 0300 GMT, June 1956. Average Height and Temperature, and Resultant Winds.



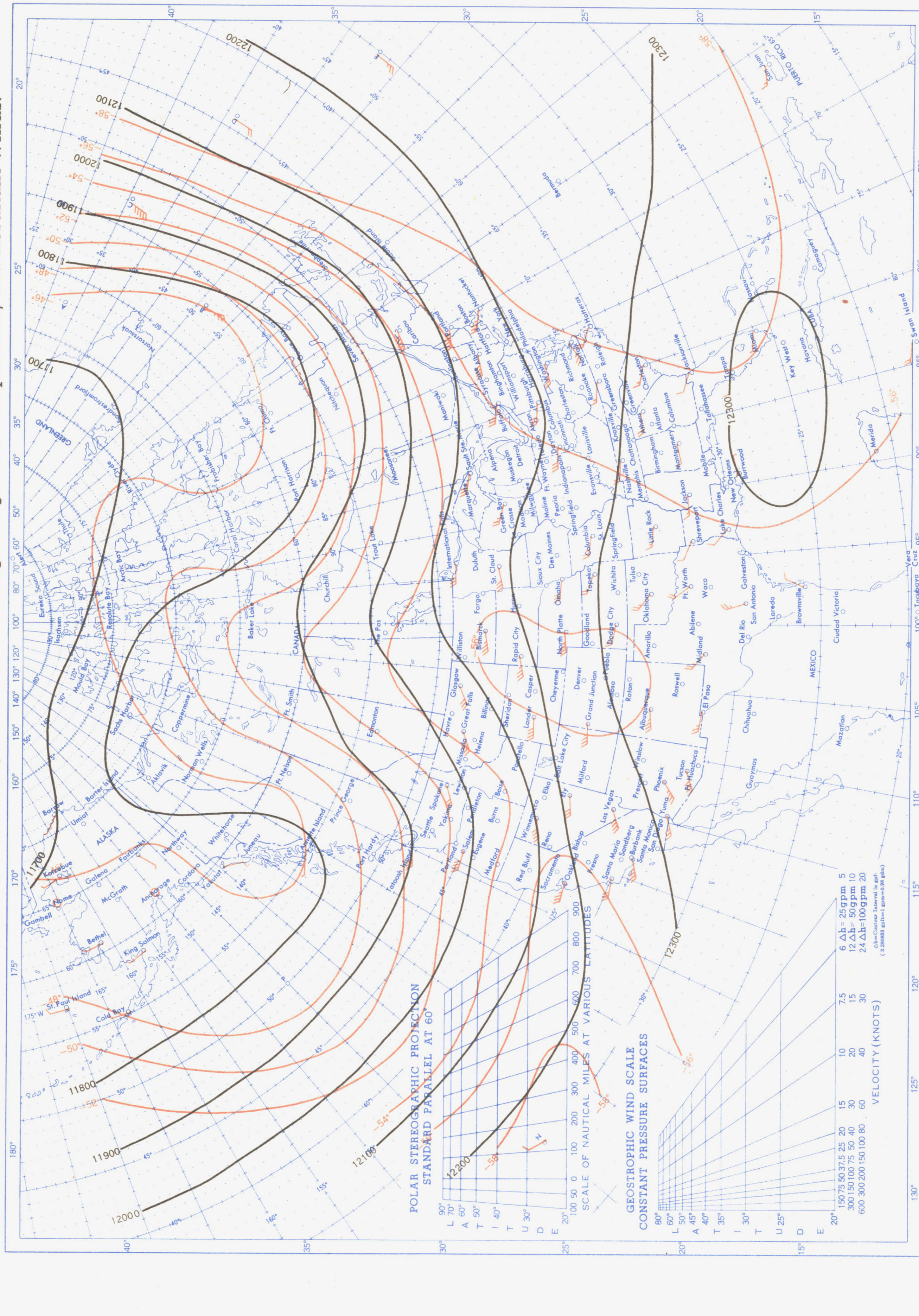
See Chart XII for explanation of map.

Chart XV. 300-mb. Surface, 0300 GMT, June 1956. Average Height and Temperature, and Resultant Winds.



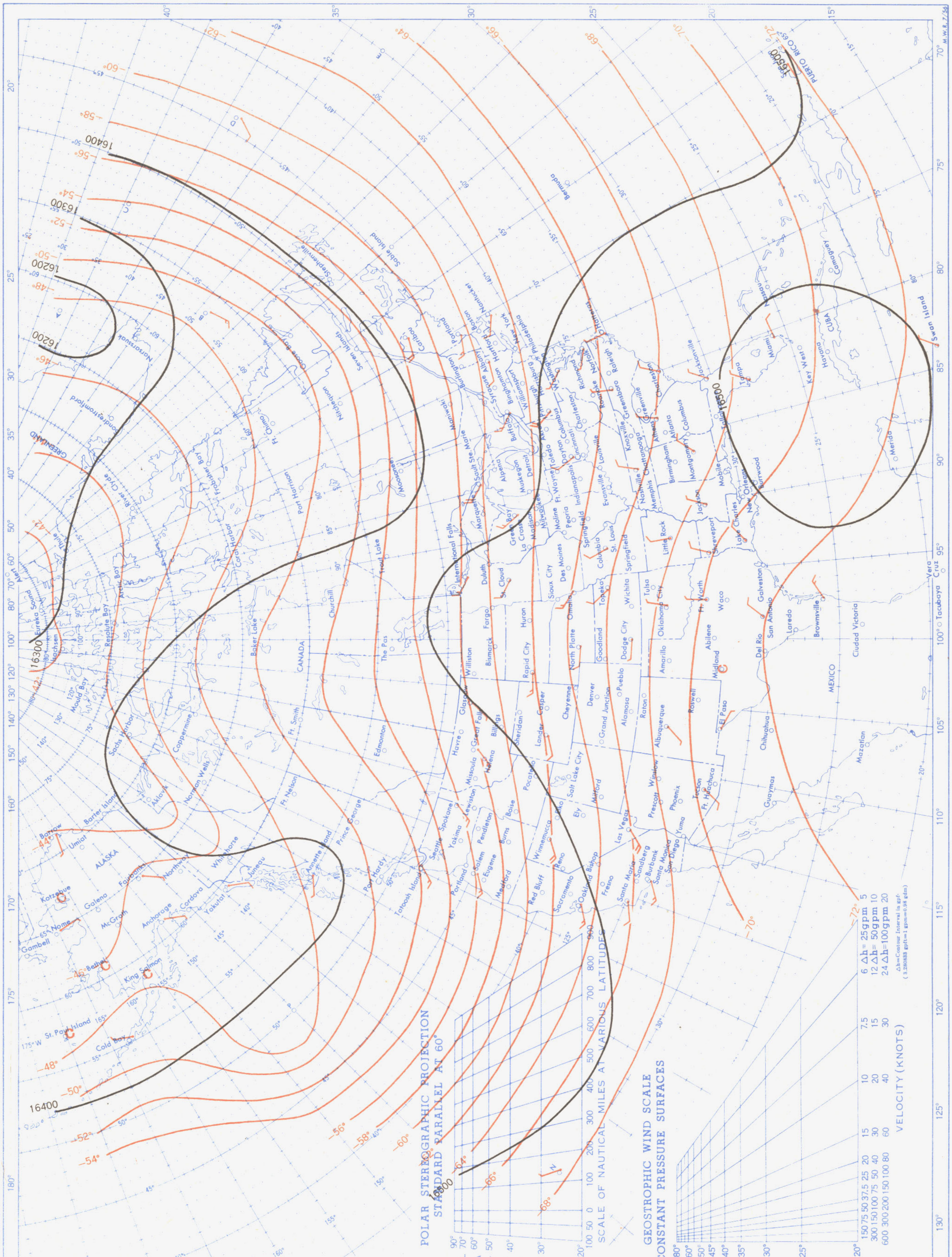
See Chart XII for explanation of map.

Chart XVI. 200-mb. Surface, 0300 GMT, June 1956. Average Height and Temperature, and Resultant Winds.



See Chart XII for explanation of map. All winds are from rawin reports.

Chart XVII. 100-mb. Surface, 0300 GMT, June 1956. Average Height and Temperature, and Resultant Winds.



See Chart XII for explanation of map. All winds are from rawin reports.